LabVIEW - Teaching Aid for Process Control

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***Abstract*—Process Instrumentation deals with measurement and control process parameters to achieve the required quality. While teaching process related subjects, it is observed that students are not able to understand process equipment and controls associated with it theoretically. So to make the subjects understandable and interesting, simulation of processes are carried out with displays as used with distributed control system (DCS). Simulations are used across virtually in engineering to improve the development process and design quality, identify design errors earlier, cut down on physical prototypes, and reduce time to market. Here dryer, boiler control simulations are carried out to study dynamic behavior. Application software LabVIEW is used with control design and data logging with supervisory (DSC) module.**

***Index Terms*—Process Instrumentation, simulation, LabVIEW, control design, DSC**

I. Introduction

The rapid adoption of the personal computer (PC) catalyzed a revolution in instrumentation for test, measurement, and automation. One major development from the utility of the PC is the concept of virtual instrumentation, which offers several benefits to engineers and scientists who require increased productivity, accuracy, and performance. Engineers and scientists, whose needs, applications and requirements change very quickly, need flexibility to create their own solutions. One can adopt a virtual instrument to one particular need without having to replace the entire device because of application software installed on the PC and the wide range of available plug-in hardware.

From the educational point of view, it is expected that the new teaching/learning technology tools available in the market may provide common experiences to cater for students who are coming from increasingly diverse backgrounds, and whose learning is best achieved in a contextual settings. However, more designing, teaching and organizational skills are now required to establish a good course material utilizing computer interaction and multimedia capabilities in engineering disciplines. Any teaching method must enable students to access without any time and distance limitations, and can allow them to use expensive laboratory experiments to which they usually have no access. However, it is not sufficient to expect that existing tools and techniques will translate simply and quickly. They have to be transformed in ways that learners and educators perceive to be useful and effective. The user friendly graphical user interface (GUI) provides a better scientific picture of the system particularly for the subjects like Process Instrumentation system, Industrial process control where the process equipment with its control, tuning methods can be visualized easily.

Engineers increasingly use simulation to meet the growing challenges of system development. Depending on the application, the simulation can be as simple as an additional software routine developed during the design process or it can be the primary medium for creating the design. It could take the form of a simple Boolean-state machine or it could require a multitude of mathematical equations to represent the behavior of a real-world entity.

There are, however, many types of simulation and corresponding technologies used to implement them today. Circuit designers simulate the performance of circuits and optimize them in a virtual environment to cut both physical prototypes and the lengthy processes required to achieve the correct design. Biomedical engineers can experiment with medical device implementation with no danger to a living test subject. Process engineers can evaluate the effects of process changes without impacting the actual production of their products. Mechanical engineers can virtually test material or geometric changes to a component, providing greater freedom to evaluate without incurring prototype costs. Controls engineers can begin developing a machine's control system while constructing it and identify possible catastrophic errors such as collisions in a virtual environment before they do any real damage.

A. Choice of Software

A number of interactive computer-delivered simulation, control, and scientific visualization software solutions are available in the market, and many application-specific tools have already been reported in the literature[1], while use diverse software such as Hypertext, Authorware, Director, Labtech, visual C++, Visual basic, Matlab/Simulink, and LabVIEW. It is found that the following criteria may be contemplated for selecting application software to build virtual instrumentation used in engineering education [2] as modularity. LabVIEW has following advantages [3]—

1) Graphical user interface
2) Drag-and-drop built in functions
3) Modular design and hierarchical design
4) Works on Multi platforms
5) Multiple high level development tools
6) Flexibility and scalability
7) Connectivity and instrument control
8) Simple application distribution
9) Open environment
10) Distributed development
11) Compiled languages for fast execution
12) Reduces cost and reserves investment

LabVIEW is one of the well-known software packages used in process control applications [4]. LabVIEW uses vari

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ous protocols such as TCP/IP, DataSocket etc. that allow remote control using internet. Several universities have developed internet-based process control laboratories for distance education using LabVIEW and its communication protocols. A remote-access control experiment laboratory was developed at the Chinese university of Hong Kong which allows users to perform control experiments over the internet [5].

The controller monitors the output and adjusts the actuators to achieve a specified response in closed loop systems. The Proportional-Integral-Derivative (PID) algorithm is the most common control algorithm used in industry [3]. The NI LabVIEW product family has control design tool which includes library of VIs and LabVIEW Mathscript functions that we can use to design, analyse and deploy a controller for linear time-invariant dynamic system model. This toolkit also includes frequency analysis, time response analysis, and classical design tools. In addition, the control design toolkit supports PID design, lead-lag compensators.

II. Methodology

Process industries such as oil refinery, paper cement industry etc, consist of process equipments like heat exchanger, boiler, evaporator, distillation column, dryer, reactor etc. It is very difficult to understand concepts of control systems associated with it without seeing it. The control systems used in industries are programmable logic controller (PLC) or a Distributed Control system (DCS) for a larger plant. As industry set ups cannot be built in laboratories, so to make understanding easier, simulation of batch reactor, dryer automation was carried out so that the students can evaluate effects of process, load variable changes without affecting actual production and avoiding hazardous situations in actual. Simulation is an efficient and inexpensive tool in control education [6].

Menu based VIs of boiler level control and dryer control are developed. VI consists of three components as front panel, block diagram and icon and connector pane. Here, front panel is similar to displays of DCS where the operator can monitor the process and can make changes in certain parameters to control it. Displays were developed with symbols of process equipments and instruments DSC module. Controller tuning parameters can be changed from front panel. Control parameters, alarm conditions with remedies, process trends, process history and controller tuning parameters can be seen by selecting the appropriate display.

Block diagram consists of control strategy. Logic to control the process is developed with mathematical functions and PID block. Control module is used for PID block. Controller mode is selected as Proportional-Integral (PI) in case of boiler level control while PID for temperature control for dryer. The controller can be configured in AUTO/ MANUAL facility.

VI is represented by icon whereas input/outputs available in VI were shown on connector pane

III. Implementation

LabVIEW version 8.2 is used to simulate boiler level and spray dryer temperature control.

Graphical, detailed and trend displays were implemented. Pictorial representation of boiler drum and spray dryer was shown on of Graphical display, complete information of process tuning parameters, constants, process variable, controller output etc by detailed displays while the graphs of process variable, controller output with set point were shown on trend displays. These displays are as shown in fig.1,2,3 for boiler level control and fig.4,5,6 for dryer control.

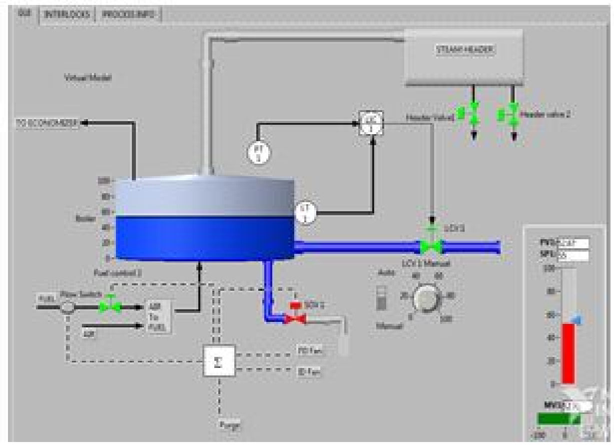

Fig 1: Graphical display —Boiler level control

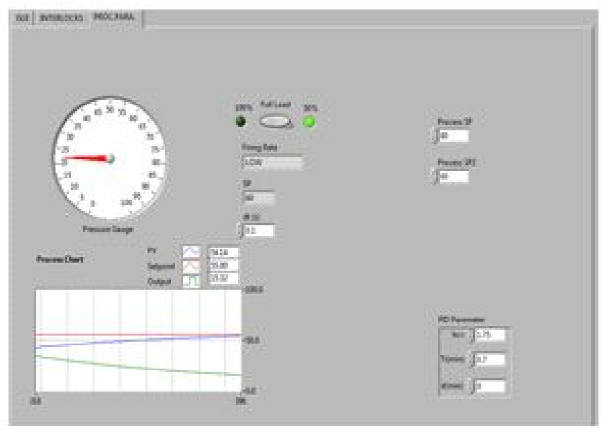

Fig. 2: Detailed display— Boiler level control

PID controller parameters selected for boiler level control are : proportional gain 1.75, integral time 0.75min and derivative time 0.00 min.

PID controller parameters selected for spray dryer temperature control are: proportional gain 20, integral time 0.008min and derivative time 0.001 min.

Safety interlocks are also implemented for both VIs.

Safety interlocks associated with boiler control:

Purge interlock: Prevents fuel from being admitted to an unfired furnace until the furnace has been thoroughly air-purged. Fuel is shut off upon loss of air flow and/ or combustion air fan, fuel supply , flame of the furnace and on lower level in boiler drum. Fan interlock: Stop forced draft upon loss of induced draft fan [7].

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Fig 3: Alarm with remedy indication — Boiler level control

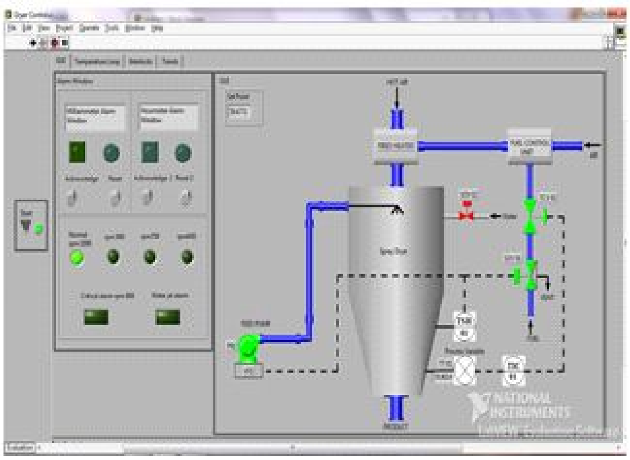

Fig 4: Graphical display—Spray dryer temperature control

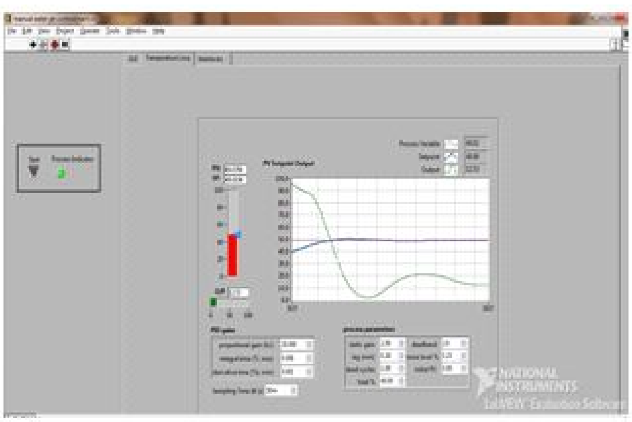

Fig 5: Detailed display— Spray dryer temperature control

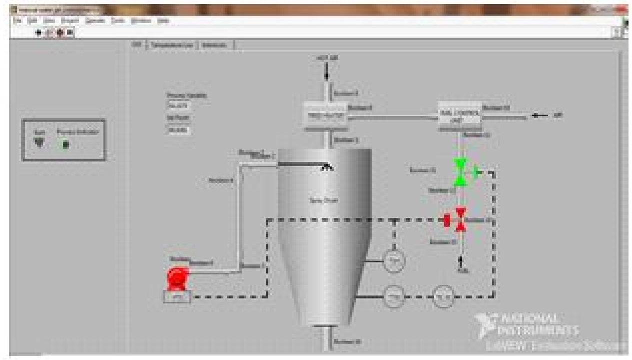

Fig 6: Alarm with tripping action—Spray dryer temperature control

Safety interlocks associated with spray dryer control:

Alarm due to high temperature inside the dryer:

When temperature inside spray dryer starts increasing, controller decreases speed of the feed pump through VFD.

For excessively high temperature, a water jet alarm is generated and a valve opens to let water into the dryer to cool it.

Alarm regarding atomizer oil:

The alarm is given out by the milliammeter due to low level of atomizer oil.

Conclusions

Students can visualize the process equipment and study the dynamic behavior of the process by introducing disturbances. It is useful to study ON-OFF and continuous controllers. The effect of Proportional, Integral, Derivative controllers and their combination on temperature control loop can be demonstrated to the students. It is not feasible to built even small scale plant in educational institutes. Hence such simulations can serve as a quasi-plant. Also it will help to learn LabVIEW features and programming as Virtual instrumentation is a part of engineering curriculum.

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